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Omega Data Bank Report (Spring through Fall 1980)

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Lorraine I. Rzonca

August 1982

Data Report

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16. Abstract

The International Bank for Airborne Omega Data continued operation at the Federal Aviation Administration (FAA) Technical Center. This report, issued by the Data Bank, is based upon 427 flight data hours covering flights in the North Atlantic, parts of the Continental United States (U.S.) and the Caribbean, South America, and Canada. These data were collected during the spring and fall of 1980; no flights were made during the summer. There were four major contributors to the Omega Data Bank during this period with three different equipment types.

Operationally usable signals corresponded quite well with the Omega signal coverage prediction diagram published by the Omega Navigation System Operational Detail (ONSOD). Exceptions were noted near Ellesmere Island for the La Reunion signal, and the continental U.S. for the Argentina signal for the specific months and times of the data flights.

Several operational differences were noted between two different Omega sets flown side by side in an FAA aircraft during flights in South America and the South Atlantic. Nonetheless, for both sets, Omega positions were within 2 nautical miles of the Inertial Navigation System position (95 percent probability) during normal flight conditions.

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METRIC CONVERSION FACTORS

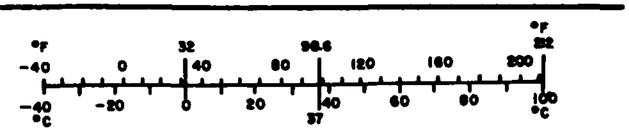
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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INTRODUCTION

PURPOSE.

This report is the second in a series of periodic technical reports which provide a standardized data presentation of Omega signal coverage (as measured by production airborne-Omega navigation systems over routes of commercial interest) under various signal environments (e.g., propagation problem regions, high solar activity). If an independent onboard position reference system is available and recorded, then Omega position differences are also presented.

BACKGROUND.

An International Bank for Airborne-Omega Data is in operation at the Federal Aviation Administration (FAA) Technical Center. This Data Bank is designed to: (1) produce empirical signal coverage charts, based upon data obtained from several different airborne-Omega navigation systems over routes of commercial interest; (2) provide a measure of the range of signal-to-noise (S/N) levels obtainable for different factors which include type of Omega set, aircraft installation configuration, geographic location, seasonal changes, and effects of high solar activity; (3) help define coverage "holes" and marginal areas where certain circumstances may produce a hole; (4) examine the role that the very low frequency (VLF) option plays in those Omega Navigation Systems (ONS) equipped to receive the United States (U.S.) Navy VLF stations as a backup to Omega; (5) provide real-world information to enhance theoretical inputs for simulation of proposed new routes; and (6) provide the capability to develop a statistical data base on Omega accuracy along world-wide air routes if contributors exercise the option to allow the recording of the Inertial Navigation System (INS) for later position comparison with the Omega data.

The Data Bank is required to handle large quantities of Omega data from various types of aircraft and from several models of Omega navigation systems. Therefore, standardization of data recording, data processing, and reporting procedures is mandatory. To optimize the efficiency of the Data Bank, members of the Omega navigation project team at the Technical Center concentrated their efforts upon the design of an airborne interface and recording set which could be easily installed and operated by commercial air carrier operators. Since the ONS data output varied among ONS manufacturers, it was necessary to specially design the interface boards for five types of ONS's. The specified design for the recording system was then furnished to Base Ten Systems Incorporated with directions to manufacture 20 cassette recorders for the Technical Center to lend to Data Bank contributors. Once a recorder is installed on a contributor aircraft, data are collected along normal air routes and the cassette data tapes are mailed to the Technical Center for processing and analysis.

Flight data are broken down to: geographic location (648 cells as shown in figure 1), date, time of day, season, propagation path illumination, known problem regions, time correlations with both solar-geophysical events, and transmitter outages.

Data collected during each season from all contributors are analyzed with results presented in a periodic Data Bank report. The Data Bank also offers three standardized data listings and plots for individual flights. Contributors may

submit written requests to obtain the listings/plots desired and/or to arrange for special listings which best fit their needs. Details of the Data Bank structure and procedures are provided in a separate report published by the FAA Technical Center, report No. FAA-CT-80-191, "System Description for the Airborne-Omega Data Bank." The "Initial Data Bank Report," covering fall 1978 through winter 1980, was published as report No. FAA-CT-80-189.

For contributors recording both ONS and INS, the latitude/longitude position difference (in nautical miles (nmi)) between the INS and ONS are shown in figures 2 through 6. Each data point represents the sampled value, recorded at 1-minute intervals, of the difference between the INS and ONS at that time. On each plot, R_1 and R_2 are the radii of circles enclosing 95 percent and 50 percent, respectively, of the data points. Since no drift corrections could be applied to the INS data, the plots do not represent accuracy data but are included as INS/ONS comparison only.

DATA BANK REPORT

SUMMARY OF FLIGHT ACTIVITY.

There were four contributors for the reporting period, March through November 1980. No flights were made in June, July, or August. The ONS types included a Tracor 7640 (150 flight data hours), two Canadian Marconi CMA-740's (204 flight data hours combined), and two Bendix ONS-20 navigation sets (73 flight data hours combined). The air routes flown include the North Atlantic, parts of the continental U.S. and the Caribbean, South America, and Canada (figures 7 through 20, respectively). Events or regional conditions which have affected Omega reception or navigation data collected by the contributors during the reporting period are shown in table 1.

SOLAR-GEOGRAPHICAL EVENTS COINCIDENT WITH FLIGHTS.

The events coincident with flight times for each contributor are listed in table 2. A large-magnitude solar flare peaked less than an hour before aircraft takeoff on March 27, 1980; however, no effects were discernible insofar as system action or recorded data were concerned. The other listed events were of smaller magnitude and also produced no observed or recorded effects on the contributor's ONS.

OPERATIONALLY USABLE SIGNALS.

S/N for each Omega station were examined from airborne data recordings to determine usable operational signal coverage. Usable signals are defined as those within a given cell, which have S/N above threshold greater than 80 percent of the time, and are deselected less than 20 percent of the time. These signals are identified on a geographic chart for each cell traversed during a flight and are compared with station coverage contours published in Omega Signal Coverage Prediction Diagrams for 10.2 kilohertz (kHz) (reference 1). The published ONSOD prediction diagrams show the global accessibility of usable 10.2 kHz signals at eight fixed diurnal/seasonal times for two signal access criteria. Criterion 1 requires: signal-to-noise ratio (SNR) $\geq$-20 decibels (dB) (in a 100 hertz (Hz) noise bandwidth) and $\Delta\phi \leq 20$ centicycles ($\overline{\text{CEC}}$), where $\Delta\phi$ is the modal interference induced phase deviation

TABLE 1. REGIONS/EVENTS WHICH AFFECT OMEGA PROPAGATION

Propagation Problem Regions	Information Source
1. Greenland Ice Cap Shadow	Westinghouse Conductivity Map
2. Antarctica Ice Cap Shadow	Westinghouse Conductivity Map
3. Nighttime Modal Interference (10.2 kHz)	ONSOD*
4. North Auroral Zone Shadow	Davies: Ionospheric Radio
5. South Auroral Zone Shadow	Propagation, April 1965, pp. 34-35 (NBS monograph 80)*
6. High VLF-Noise Area	CCIR 322 publication*

Events	Information Source
1. Solar X-Rays	NOAA "Preliminary Report and Forecast of Solar & Geophysical Data" (PRF) (weekly)*
2. Polar Cap Disturbance (PCD)	ONSOD teletypes*
3. Magnetic Storm	NOAA "PRF" (weekly)*
4. Station Power Reduction/Outage	ONSOD teletype (weekly)*

*Note: ONSOD = Omega Navigation System Operations Detail (U.S. Coast Guard)
NBS = National Bureau of Standards
CCIR = International Radio Consultative Committee
NOAA = National Oceanic and Atmospheric Administration

TABLE 2. SOLAR-GEOPHYSICAL EVENTS COINCIDENT WITH FLIGHTS

Contributor No.	Date (1980)	Event
1	3/2	Transmitter outage, Station A
1	5/17	Transmitter outage, Station E
2	3/27	Solar flare of magnitude M5

ǝ signal phase relative to the reference signal phase. Criterion 2 differs :riterion 1 in that the SNR is $\geq$-30 dB. The eight Omega station diagrams are ıted over eight selected coverage times for a total of 64 individual diagrams. diagram contains the S/N and $\Delta\phi$ contours for a designated signal access ·ion and coverage time.

; the spring 1980, Contributor No. 2 followed the North Atlantic flightpath in figure 8 for 8 day and 6 night transatlantic flights. From the data led during these flights, two composite diagrams, one for day and one for flights, are shown as figures 9 and 10, respectively. These figures depict ıega signals which were received with an operationally usable signal strength :h cell on the flightpath. It is interesting to note that the majority of ın deselections and substitutions occur along the U.S. east coast. The letter ıators for each station are as follows:

ı - Norway
| - Liberia
: - Hawaii
ı - N. Dakota
; - La Reunion
' - Argentina
; - Trinidad
[- Japan

·iewing usable signals present in figures 9 and 10, Station E at La Reunion is as an example of the analysis performed to determine station performance. composites show selection of station E was not attempted and automatic ction of the station was made by the Omega computer. The La Reunion (E) tion Diagrams (figure 11) show coverage encompasses most (0600 Greenwich mean GMT)) or all (1800 GMT) of the North Atlantic. The primary reason for the tic deselection was unacceptable $\Delta\phi$, although the S/N was in the -30 dB in more than 50 percent of the cells flown. Analysis of this type was med to verify the cell coverage of other stations.

analysis of Station A indicates complete coverage through each cell flown. ly marginal problem area was the east coast of the U.S. Station B followed a r pattern except for a complete dropout in cells Nos. 529 and 494. Station C ot selected although the prediction diagram indicated acceptable S/N values. Station D showed strong signal coverage in all cells. Station F t selected in any of the cells flown. The S/N was within the -20 dB receive and the $\Delta\phi$ level was also within acceptable limits, but the reason for non- ion is not known. Station G showed usable signal in all cells. No predic- harts were available for G (Trinidad) since the station will be replaced in y Australia. Station H was not received over water, although reception was in cells 492, 494, and 529. The prediction chart for Station H indicates an tio $\geq$-30 dB range.

ite figure 10, "Night," indicates Stations D and G signals present in cells 90, 491, and 492. This diagram differed from the "Day" composite only in tations A and B were not received, although the predicted S/N and $\Delta\phi$ for stations were in the acceptable region. Possibly this Omega set was very ıative in the deselection software and excluded those stations along with the ime Liberia signal over a larger geographic area than was required.

Limited flights over the U.S. were flown by Contributor No. 2 during spring 1980, as shown in figure 12. Data were recorded from 2100 through 0800 GMT. Usable signal coverage by cells are presented for code 02/02/02 contributor in composite figure 13.

Lack of Station A signal west of cells Nos. 495 and 460 shows good correlation with the ONSOD coverage diagram since the prediction diagram indicates S/N ratio in the $\geq$-30 dB region.

Station B signals were either absent or marginal throughout all cells, although prediction indicated a -20 dB S/N ratio presence. The signal was identified by the receiver as unusable due to the large $\Delta\phi$ which covered a major portion of the U.S. Stations C and D signals are present as predicted by the coverage diagram over the U.S.

Station E's absence was indicated when all cells fell within the modal interference region. In addition, S/N ratio was $\geq$-30 dB.

Station F was received in only one cell, although acceptable signal levels were predicted. No modal interference was predicted for the U.S. east coast.

Station G signal was present; no prediction diagrams were available on this station.

South American flights, made by Contributor No. 3 during spring 1980, followed the flightpath shown in figure 14. Flight data were recorded from 2100 through 0500 GMT. Usable signals are presented in composite figures 15 and 16 for two contributor Omega equipments.

Operationally usable signal chart (figure 15) show that Omega set 01 received stations A, C, D, and E in all but a few cells, although stations A and E had a predicted S/N ratio between the -20 to -30 dB. Station B was not received in cells Nos. 384, 385, 349, 313, 277, 348, 311, 310, and 309. The signal coverage prediction diagrams for Station B (spring) show that the S/N contour lines encompass the particular cells of the flightpath where no signal was received and are between the ratios of -20 and -30 dB. It should have been received. Deselection due to modal interference protection was observed on Stations G and F. Airborne Omega navigation systems minimize modal interference problems by automatic deselection of an Omega station when the range is less than 600 nmi.

One notable difference with Omega set 01 compared to the prediction diagram was the absence of Station H throughout the flight in South America. Also, the prediction diagram for Station H shows the S/N ratio was in the -30 dB contour and the $\Delta\phi$ level exceeded the normal along the South America coast. Another difference was that Station C was deselected off the coastline of Africa where S/N was within the -30 dB contour. Finally, although $\Delta\phi$ was predicted to be greater than 20 CEC for Station E north of Rio De Janiero, the contributor set did not deselect to protect against modal interference.

Omega set Contributor 3 (figure 16) used Omega Stations B,C, and D throughout all cells flown during the South America flight. The Omega set 03 computer did deselect Station G and partially deselected, depending on geometry, Stations A and F south of Buenos Aires, Argentina. The latter deselection was to minimize interference associated with the flightpath which was in close proximity to the station

transmitter. Station H was deselected in all cells east of an imaginary line drawn from cell Nos. 348 to 204. Also, Station E signal reception northwest of Rio De Janiero was not present above an imaginary line drawn through cells Nos. 277 to 311.

Comparing signal coverage prediction diagrams for Stations B, C, and D, spring season (reference 1), against the flight data recorded, the S/N ratio of -20 dB contour for Station B was superimposed over the flightpath flown; while for Stations C and D it was well within the -20 dB contour line. The 03 receiver had a better than average reception for these selected stations. Station A, south of Buenos Aires, lies within the -30 dB region. Therefore, the station was deselected. Station H diagram from the 60° W longitude line east to the South Atlantic, indicates Omega VLF S/N ratio is in the -30 dB or cutoff region for this contributor set.

Data recorded on Omega sets by Contributor No. 5 in Canada (see figure 17) during September and October 1980 showed good correlation with ONSOD coverage diagrams for a -30 dB receiver. One exception was in the case of the Omega signal from Liberia (B) for which the -20 dB coverage contour seemed to apply. Figure 18 shows the stations recorded as usable for navigation within each cell. Stations marked with an asterisk were not usable all of the time because the -30 dB coverage contour passed through the cell and the contour location varied with GMT. Station A (Norway), when followed with a plus, was not usable all of the time because the -30 dB coverage contour varied seasonally (i.e., varied by the month rather than by the time of day). The September coverage for Station A was less than the coverage in October because of the increased daylight in Greenland, resulting in a corresponding increase of attentuation for Norway signals. Although the Omega coverage was generally consistent with the ONSOD coverage diagrams, an exception was seen in cells 637 and 638 where Station E (La Reunion) should have been received, but actual S/N numbers were below threshold.

The Omega set used by Contributor No. 5 was equipped with VLF backup. Cells in which VLF was sometimes used to supplement Omega are marked with V1 and V2 in figure 18. It was noted that the Omega set included the VLF mode whenever the S/N number for Station A (Norway) was low and the GMT was between 1900 and 0800 (Greenland night); this situation is represented by V1. Between 0800 and 1900 GMT, the Omega set included VLF whenever the S/N number for Station H (Japan) was low. This situation is represented by V2.

Two short flights made by Contributor No. 6 during September and October (see figure 19) provided Omega coverage information for the cells shown in figure 20. The two-digit number represent the GMT for the flight. This Omega set used the Trinidad Station in the "G" slot. For this Omega set and installation configuration, Omega coverage was consistent with the -20 dB contour of the ONSOD coverage diagrams. The only exception was S/N numbers below threshold for Station D (North Dakota) during the flight through cells 458 and 459; the sudden and complete loss of signal looked like a station outage, although no correlation was found with published outages (i.e., from ONSOD teletypes).

POSITION DIFFERENCES FOR DUAL INS/ONS INSTALLATIONS.

Between April 19 and May 5, 1980, the FAA Technical Center and ONSOD collected Omega data onboard an FAA Convair CV-880 in South America. For ONSOD, the flights comprised part of their ongoing Omega system validation effort. The FAA collected

operational Omega data from two types of production Omega navigators, referred to as sets 01 and 03 in this report. An INS provided reference position.

Scatter plots were made of the Omega position compared to the raw INS position (i.e., uncorrected for drift). Circles were drawn which enclosed 95 and 50 percent of the data points on a scatter plot. The radii of these circles were denoted R1 and R2, respectively. Comparisons of R1 and R2 values were made for the two Omega sets. These data are presented in table 3 where values are categorized according to four different flight conditions.

Under normal conditions, both Omega sets showed the same general range for values of R1 and R2. The average values for set 01 are slightly higher than those for set 03. The ratio of R1 and R2 ranges from 1.8 to 4.7, while the ratio for the six normal flights was approximately 2 for both sets.

For those flights during which aircraft power spikes occurred, R1 values for set 01 increased significantly. The reason for this was a jump in Omega position error after the power spike occurred, with several minutes required for recovery. The worse power spike occurred on the probe flight out of Ascension (even the autopilot was affected); the jump in Omega position is indicated in the scatter plot for set 01 shown in figure 2. Set 03 exhibited the same behavior, although the magnitude of the position jump was approximately one-half that of set 01 and the recovery time was approximately one-third that of set 01.

TABLE 3. VALUES FOR R1, R2, R1 (AVG)/R2 (AVG) UNDER DIFFERENT FLIGHT CONDITIONS

		R1 (nmi)			R2 (nmi)			
Flight Conditions	ONS	Low	High	Avg	Low	High	Avg	R1 Avg/ R2 Avg
1. Normal (6 flights)	01	1.7	4.2	3.0	0.9	2.1	1.5	2.0
	03	1.5	4.1	2.4	0.7	2.6	1.3	1.9
2. Aircraft power spikes (3 flights)	01	3.8	5.7	4.6	1.4	1.5	1.4	3.3
	03	1.7	4.0	3.0	0.7	1.9	1.2	2.5
3. INS update inflight (1 flight)	01			8.8			3.6	2.4
	03			5.0			2.3	2.2
4. Inflight reinitializations of ONS (2 flights)	01	3.1	8.3	5.7	1.1	1.3	1.2	4.7
	03	7.0	9.7	8.3	4.5	4.7	4.6	1.8

NOTE: R1 and R2 are radii of circles which enclose 95 and 50 percent, respectively, of the data points on a scatter plot. The data points show position differences between the Omega set and the onboard INS position reference system. No drift corrections were made for INS data; the values for R1 and R2 should not be interpreted as Omega accuracy figures.

During one flight the INS was updated in flight over a known waypoint. The effect was to increase the ratio of R1 to R2, as compared to normal flight conditions, for both sets.

On occasion, the Omega operator reinitialized the Omega set in flight, using the INS latitude/longitude for reference. This procedure was carried out when the Omega latitude/longitude seemed to be significantly different from that of the INS. In the flight from Ascension to Recife, system power was lost on takeoff and both Omega sets were initialized when airborne after power was restored. On the flight from Recife (located on the geomagnetic equator) to Belem, both Omega sets developed large errors (5 nmi by set 01, 20 nmi by set 03) compared to INS and were reinitialized in flight. As a result, the R1 values were large, especially for set 03. Sometimes the reinitialization procedure did not seem to correct the Omega latitude/longitude and multiple reinitializations were done. Thus, the values for R1, R2, and the ratio of R1 to R2 could take on large values if the reinitialization procedure produced larger errors rather than smaller ones. A sample of this problem is given in figure 3 where set 01 had large errors after takeoff from Ascension and three reinitializations were performed before the proper latitude/longitude was achieved.

Large drift errors in Omega position were noted on those flights originating from Santa Cruz and from Recife. Both of these airports are very close to the geometric equator. From Santa Cruz to Cordoba, both set 01 and set 03 showed a gradual northeast drift of about 4 nmi/hour. From Recife to Ascension, a 2.5-hour flight, set 03 showed a total westerly drift of about 7 nmi, as shown in figure 4. In set 01 a position drifting to the east, then to the west, then to the east, all within a 4-nmi band. From Recife to Belem, set 03 showed an easterly drift of about 3 nmi/hour; set 01 showed drifting along a southwest-northeast line within a 4-nmi band. Flights originating from other airports did not seem to indicate Omega position drifting errors. Additional data would be required to determine whether such drift errors are related to location at the geomagnetic equator.

During the flights from Cordoba to Trelew and from Trelew to Rio De Janiero, set 03 deselected Station A (Norway) because phase anomalies are predicted for this region for the GMT corresponding to the flights. However, set 01 continued to use Station A. Scatter plots for these flights showed more scatter in the set 01 data points, as shown in figure 5. Set 01 showed a northing error which was 2 nmi greater than that of set 03 as shown in figure 6.

HIGHLIGHTS OF PROBLEM AREAS.

Omega latitude/longitude was compared to actual latitude/longitude at several airports in South America during the FAA flights on the CV-880. Omega set 01 showed easterly biases (0 to 1 nmi) in all cases. Omega set 03 showed a 5-nmi bias to the west at the end of the flight from Recife to Ascension; otherwise, biases were easterly (0 to 5 nmi) south of the equator and westerly (2 nmi) north of the equator.

The data on Omega northing errors showed an interesting correlation with distance from the geomagnetic equator. Figure 21 shows the CV-880 route map. The airports where Omega set latitude/longitude was compared to actual latitude/longitude (see reference 2) are identified; the northing errors (nmi) are noted for Omega set 03 and the approximate location of the geomagnetic equator is sketched. Airports north of the geomagnetic equator showed biases to the south, while airports south

of the geomagnetic equator showed biases to the north. The magnitude of the bias increased with distance from the geomagnetic equator. Omega set 01 exhibited the same behavior except that the bias errors were larger.

Since this particular route structure was only flown once, a firm conclusion cannot be drawn. Additional data, possibly from Data Bank contributors who may want to make a note of end point latitude/longitude and include this information along with the corresponding cassette data tapes, would be needed to corroborate these northing errors.

COMMENTS.

1. This second report issued by the Data Bank is based upon 427 hours of data collected during the period from spring through fall 1980. During the months when the above flights were made, there were 179 solar flares (of magnitude M2 or greater), but only 1 was coincident with recorded flight data which had no significant effects on observed S/N values.

2. The only blunder errors which were apparent in data collected to date occurred when the ONS operator inadvertently entered the incorrect date or incorrect GMT during system initialization. Such errors may not always be obvious when data are scanned prior to entry into the data base and would produce erroneous time-correlations with events listed in the data base.

3. Operationally usable Omega signals derived from the contributor data corresponded quite well with the Omega signal coverage prediction diagrams published by ONSOD. Loss of reception of certain signals due to time of day or to seasonal variations coincided with the predictions in most instances.

4. Exceptions to the predicted diagrams were noted for station E (La Reunion) in the vicinity of Ellesmere Island (cells 637 and 638, northwest of Greenland) during the flights in Canada by Contributor No. 5. For La Reunion, the -30 dB contour seemed to apply, except for Ellesmere Island where reception was degraded so that a -20 dB contour applied.

The same exceptions to the predicted diagrams were noted for Liberia where a -20 dB contour seemed to apply. The coverage in Canada for the other Omega stations corresponded with prediction diagrams for a -30 dB receiver.

5. Another exception to the prediction diagrams was noted in data from Contributor No. 2 during flights over the continental U.S. Station F (Argentina) was received on only one cell, although the signal was predicted to be usable throughout the area flown.

6. Operation of two different Omega sets (sets 01 and 03) during FAA flights in South America and the South Atlantic points out several operational differences. Set 01 could not receive Station H (Japan), although set 03 received the signal west of the 60° W longitude line (approximate boundary for -30 dB coverage). Set 01 did not automatically deselect Station E (La Reunion) north of Rio de Janeiro, although Omega phase deviation greater than 20 CEC was predicted for this region; set 03 did deselect Station E. Set 03 deselected Station A (Norway) south of the 15° S latitude, corresponding to predicted $\Delta\phi$ 20 CEC during the flight time,

whereas set 01 did not deselect station A. As a result, set 01 showed a significant northing error (2 nmi) and greater scatter in the position data. Set 03 returned to normal operation (correct position) approximately three times more rapidly than did set 01 after aircraft power spikes.

REFERENCES

1. Gupta, R. R., Donnelly, S. F, Creamer, P. M., and Sayer, S., Omega Signal Coverage Prediction Diagrams for 10.2 kHz, Volume II Individual Station Diagrams, Analytic Sciences, Corp., TASC-TR-3077-2, October 1980.

2. DOD Flight Information Publication (Terminal), High and Low Altitude Carribbean and South America 1980 Airfield Diagrams, published by Defense Mapping Agency Aerospace Center, St. Louis A.F. Station, Missouri.

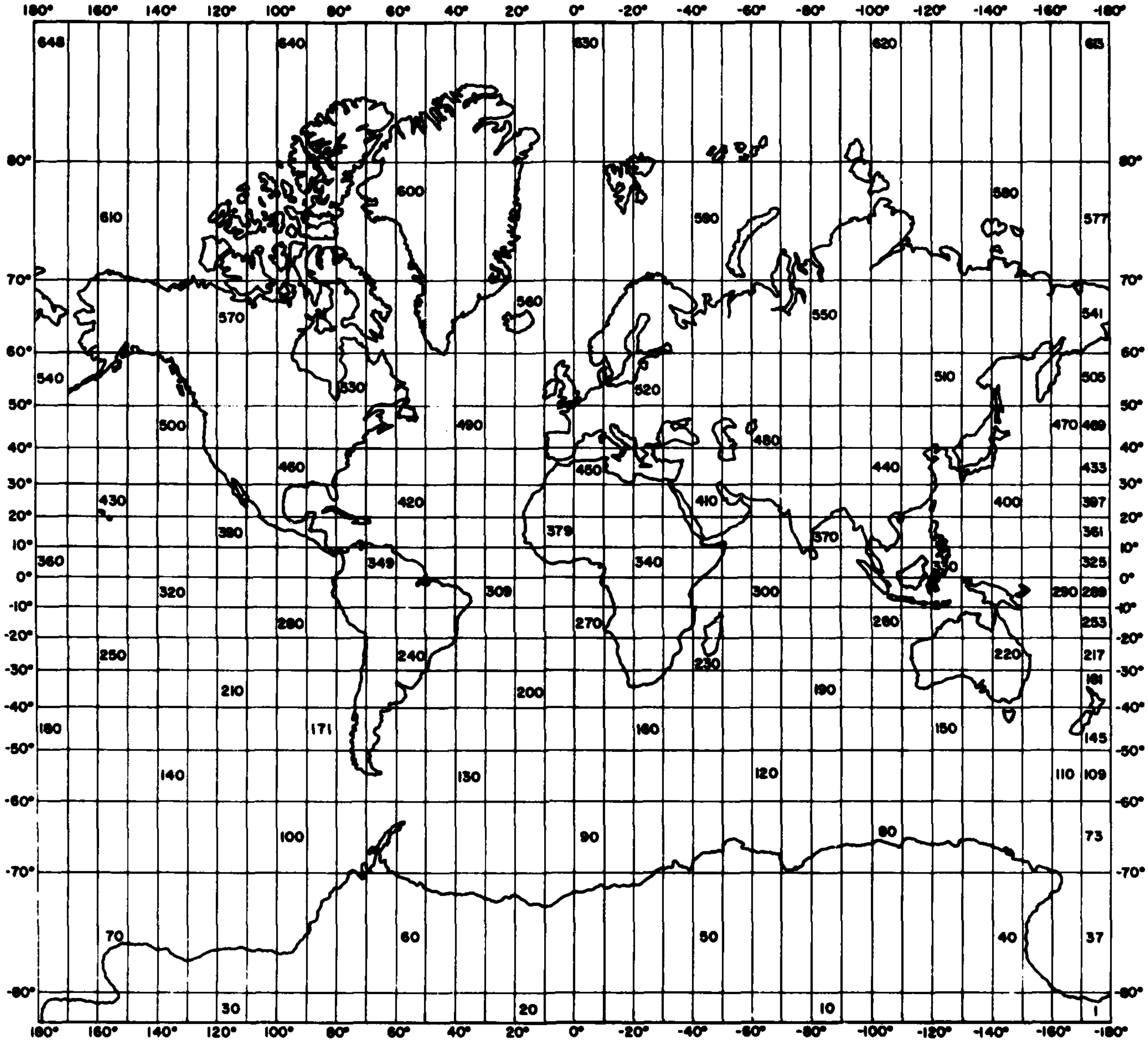


FIGURE 1. AIRBORNE-OMEGA DATA BANK CELLS

FAA CV-880 RADII.50%CIRCLE: 1.46 95%CIRCLE 5.73

DATE 43080 START 21.55 STOP 0.85 ONS
COORDINATES OF CENTROID. X= -1.67 Y= 2.11

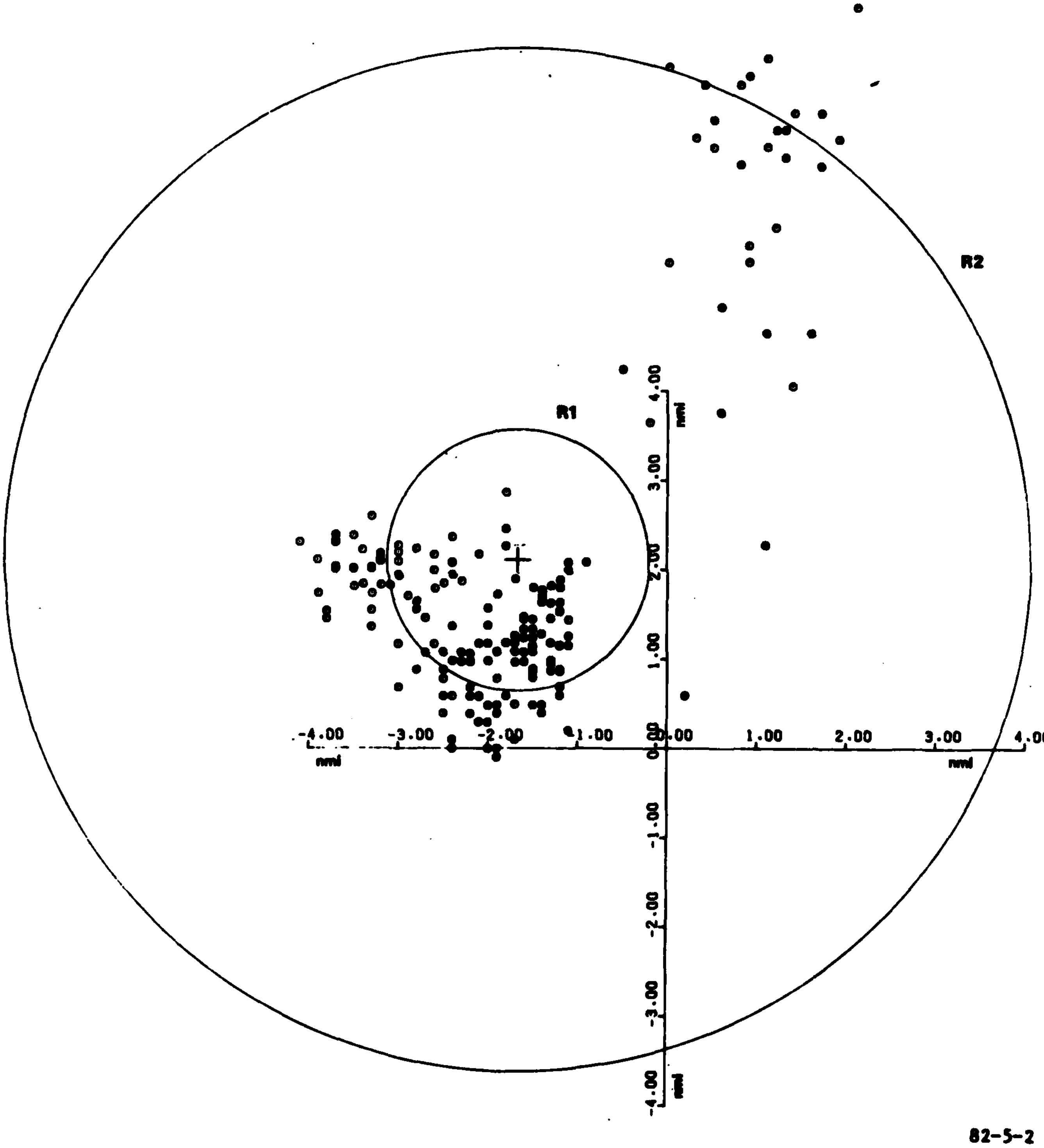


FIGURE 2. PROBE FLIGHT, ASCENSION ISLAND, SCATTER PLOT OMEGA SET 01 VERSUS INS

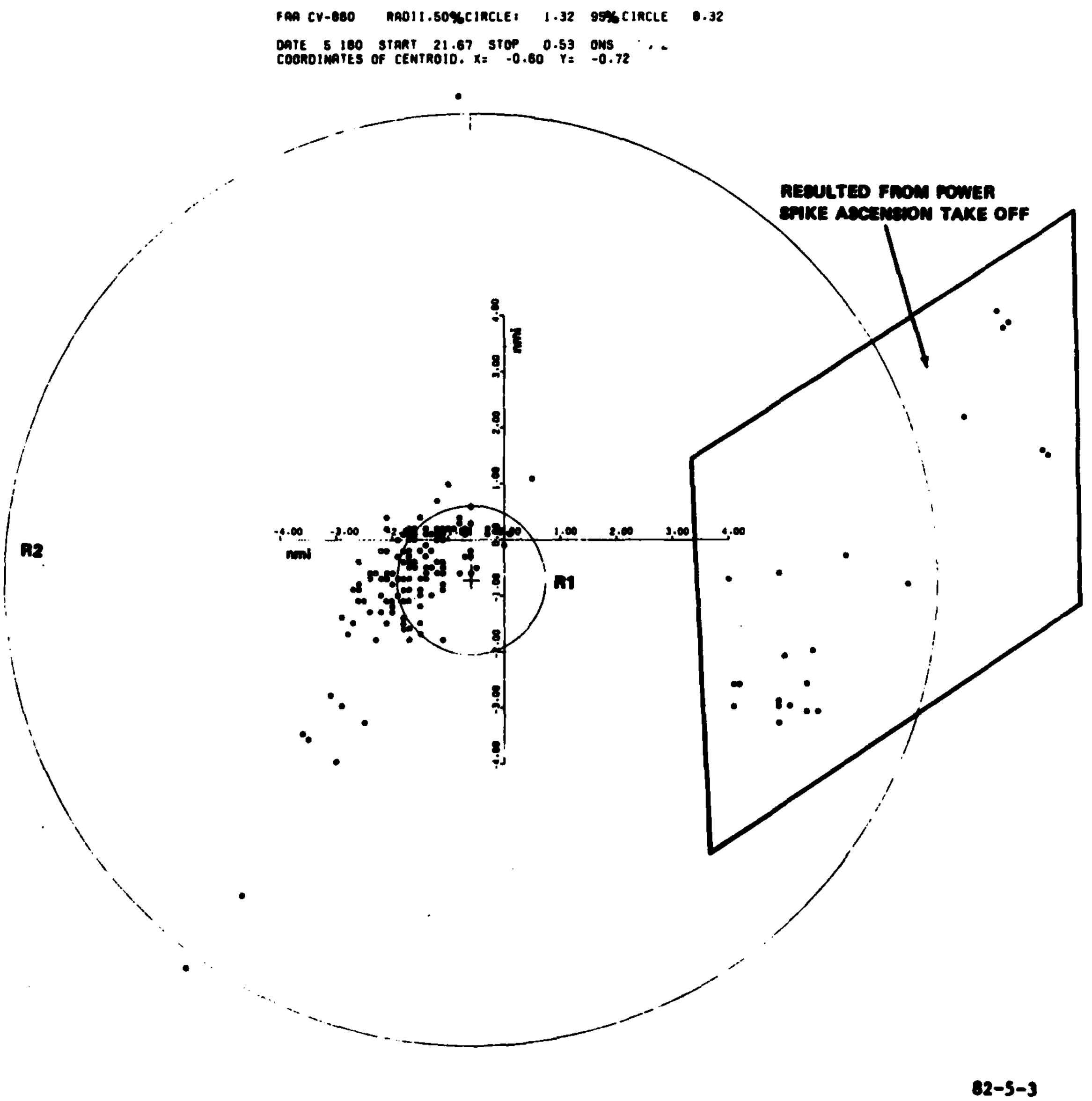
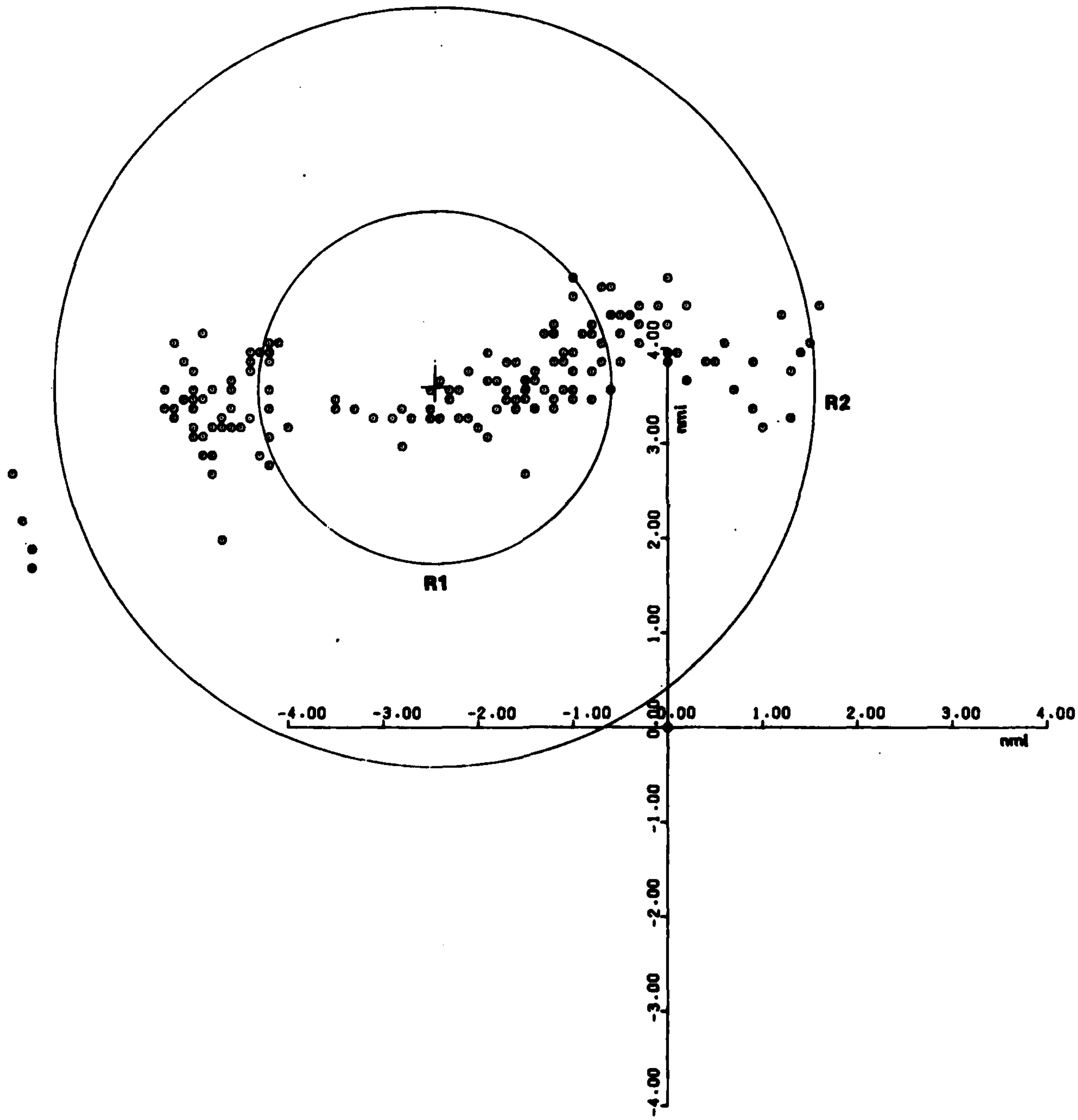


FIGURE 3. EN ROUTE FLIGHT, ASCENSION ISLAND TO RECIFE, BRAZIL, SCATTER PLOT OMEGA SET 01 VERSUS INS

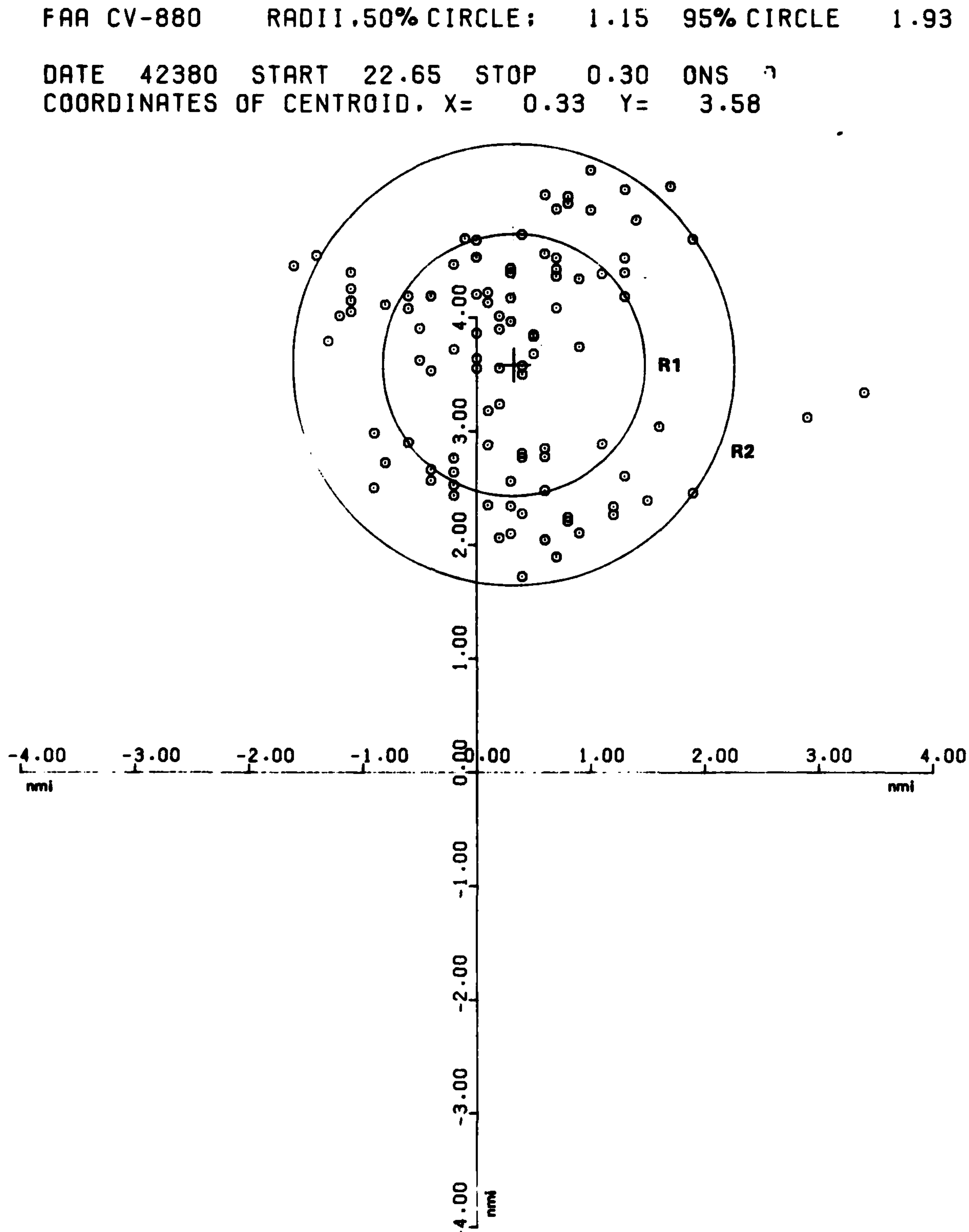
FAA CV-880 RADII.50%CIRCLE: 1.86 95%CIRCLE 4.01

DATE 42980 START 23.07 STOP 1.75
COORDINATES OF CENTROID. X= -2.45 Y= 3.59



82-5-4

FIGURE 4. EN ROUTE FLIGHT, RECIFE, BRAZIL, TO ASCENSION ISLAND, SCATTER PLOT OMEGA SET 03 VERSUS INS

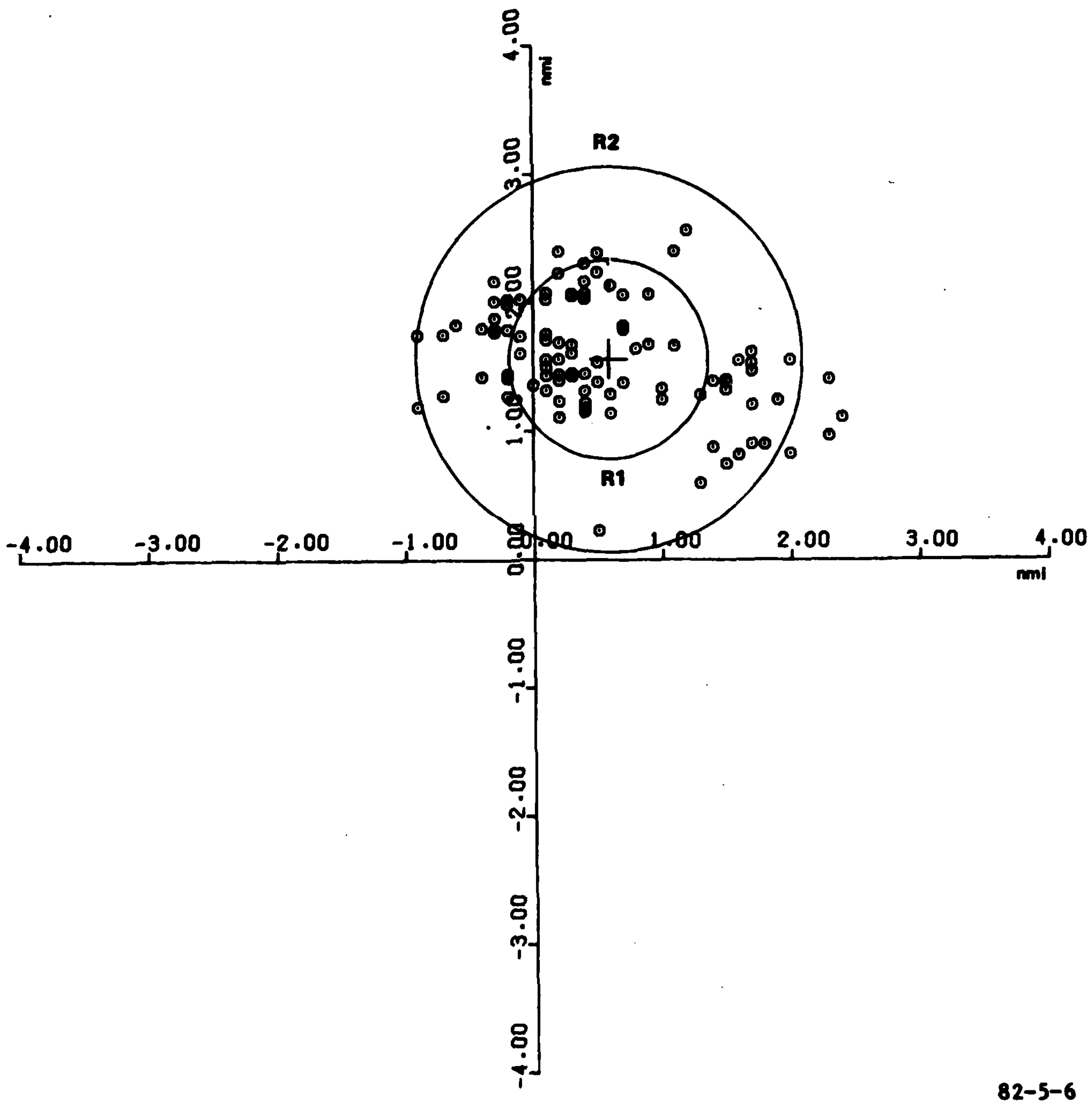


82-5-5

FIGURE 5. EN ROUTE FLIGHT, TRELOW, ARGENTINA TO RIO DE JANIERO, SCATTER PLOT OMEGA SET 01 VERSUS INS

FAA CV-880   RADII.50% CIRCLE: 0.77   95% CIRCLE   1.50

DATE 42380 START 22.65 STOP   0.30 ONS
COORDINATES OF CENTROID. X=   0.59 Y=   1.56



82-5-6

FIGURE 6.   EN ROUTE FLIGHT, TRELOW, ARGENTINA, TO RIO DE JANIERO, SCATTER PLOT OMEGA SET 03 VERSUS INS

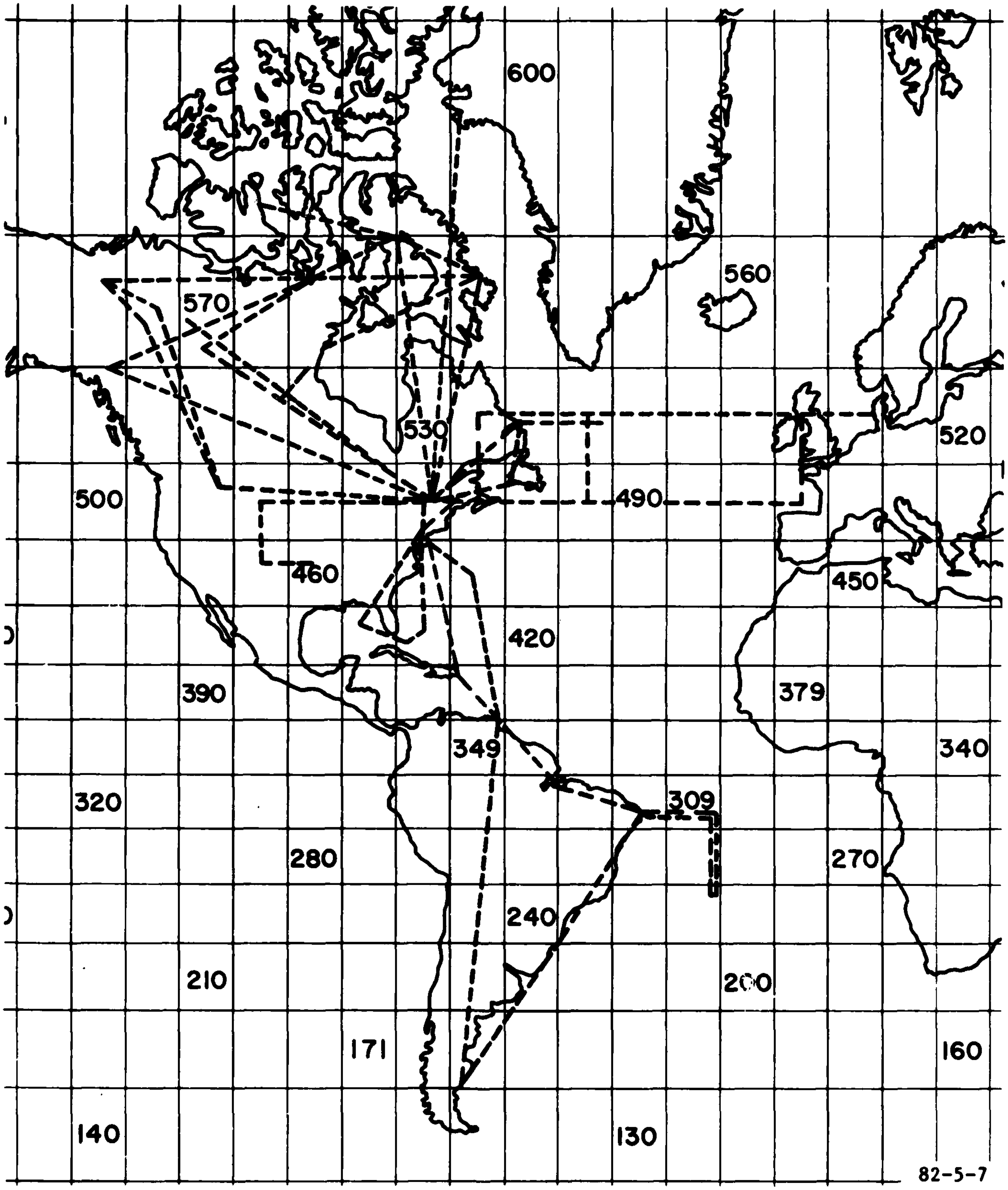
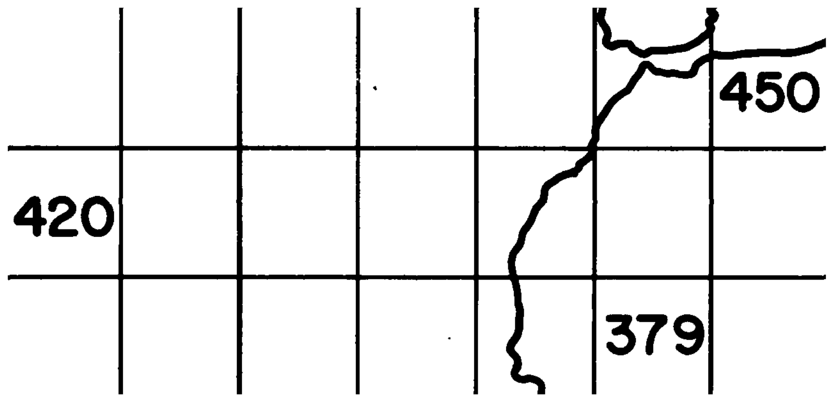


FIGURE 7. CONTRIBUTOR AIR ROUTES


450
420
379

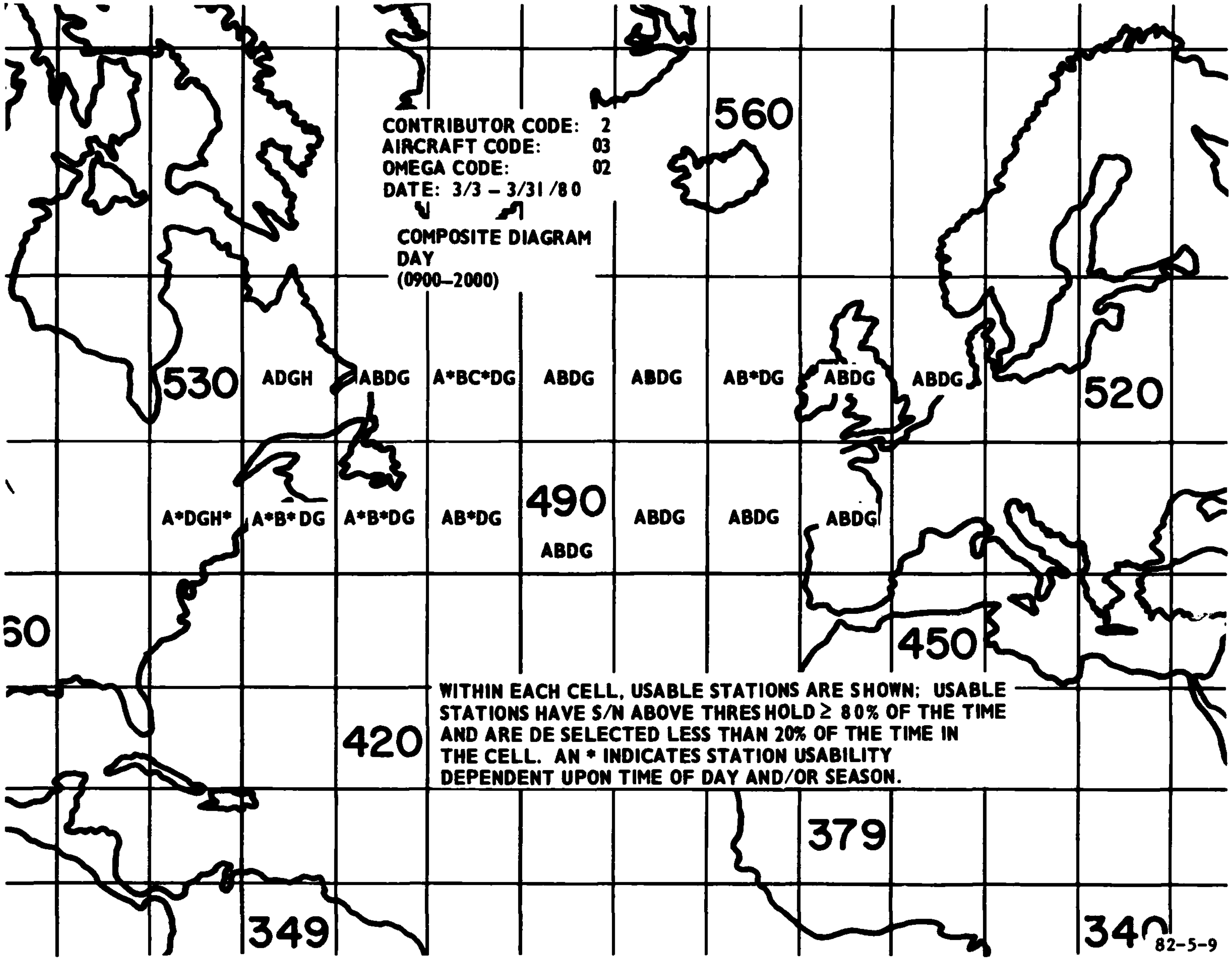


FIGURE 9. OPERATIONALLY USABLE SIGNALS: NORTH ATLANTIC — "DAY"

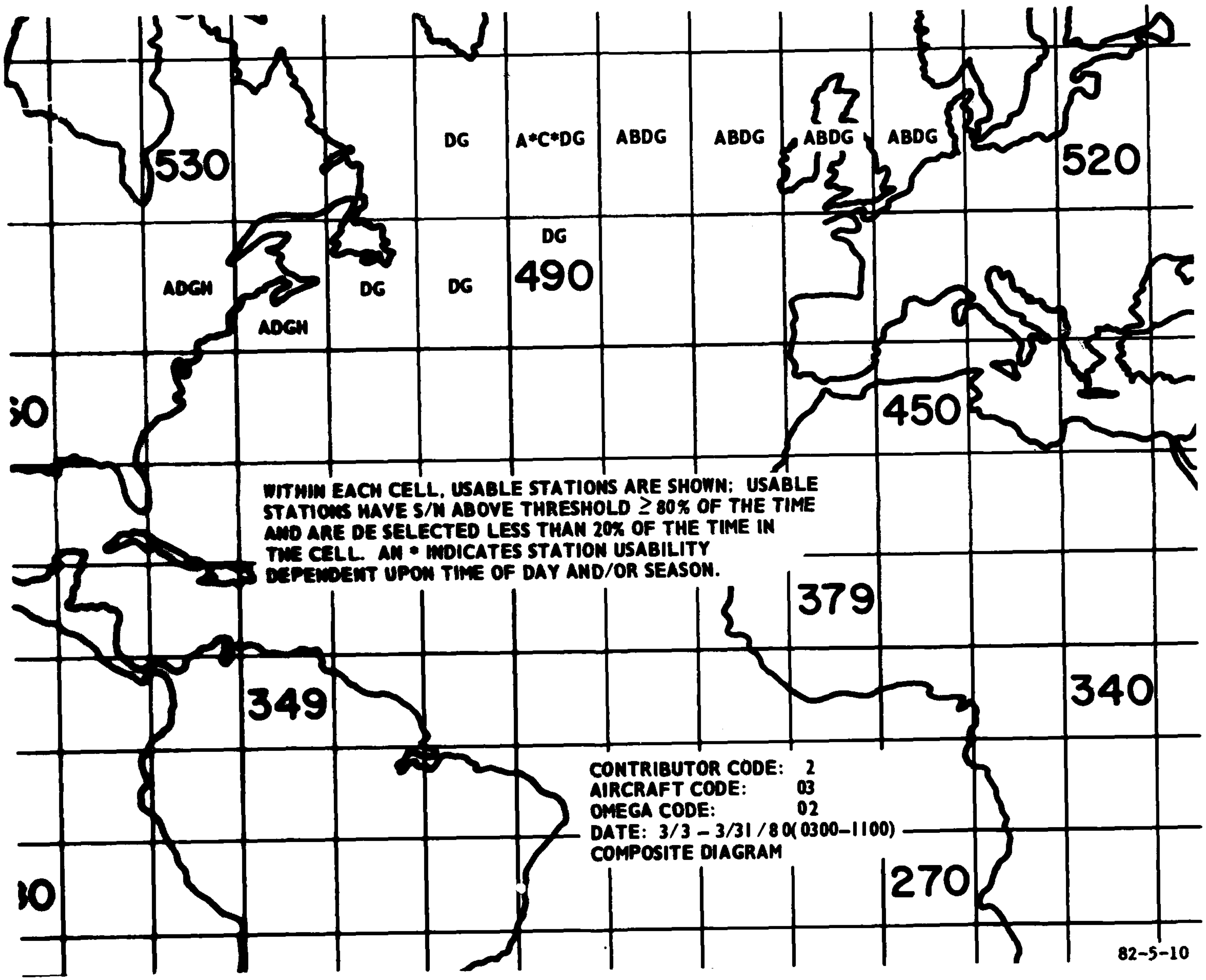
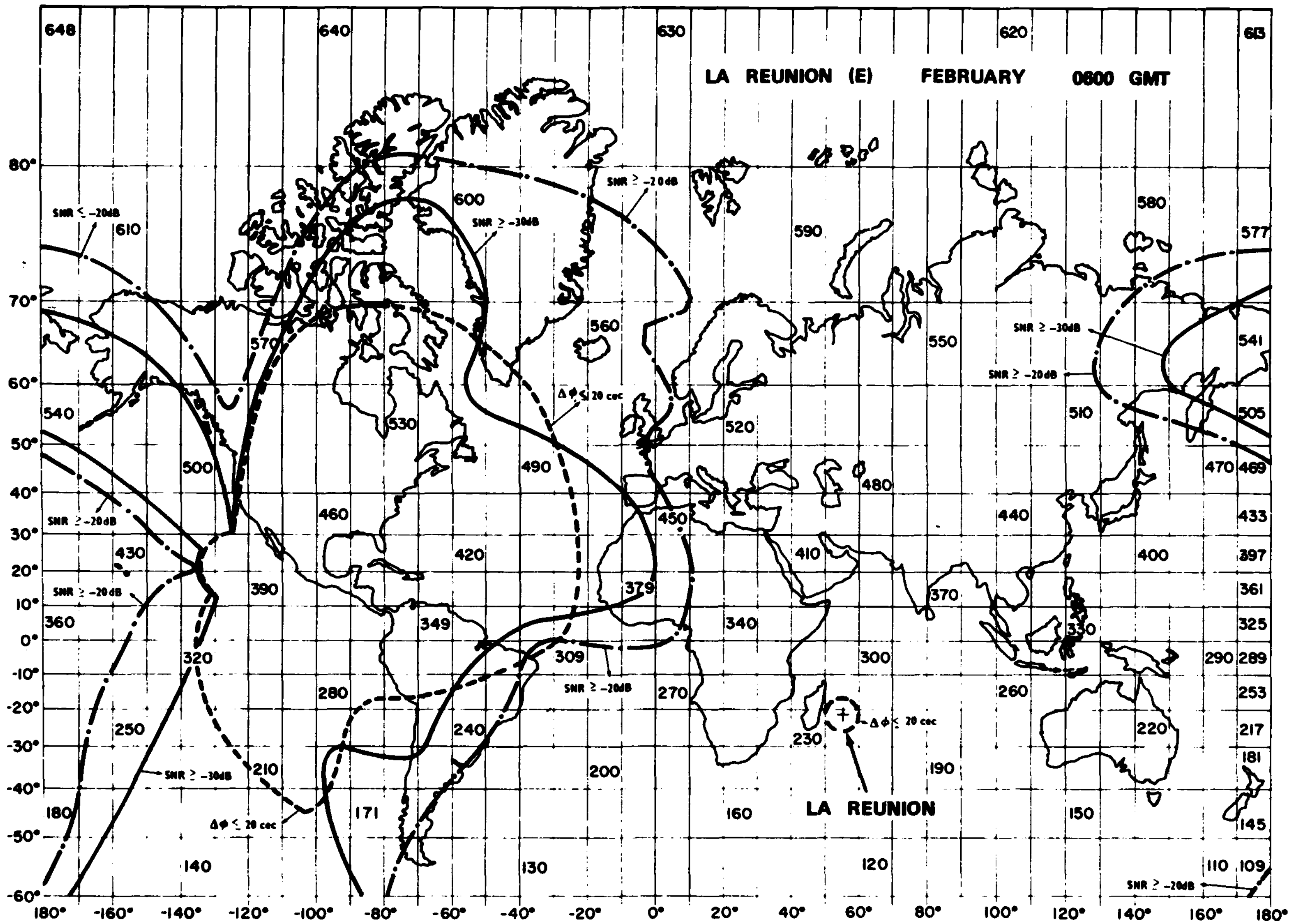


FIGURE 10. OPERATIONALLY USABLE SIGNALS: NORTH ATLANTIC — "NIGHT"



82-5-11a

FIGURE 11. OMEGA SIGNAL COVERAGE PREDICTION DIAGRAM LA REUNION (E) (SHEET 1 OF 2)

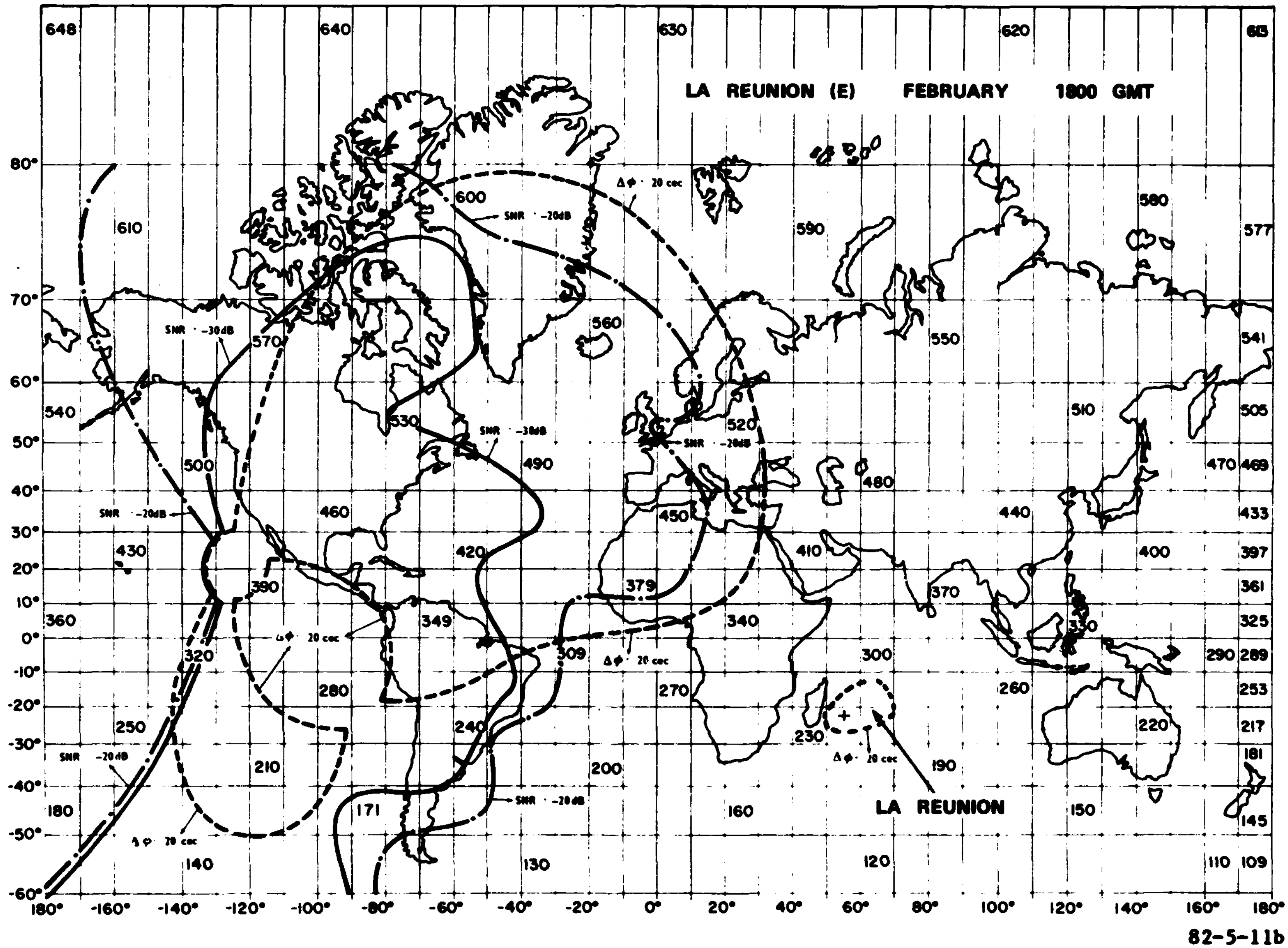


FIGURE 11. OMEGA SIGNAL COVERAGE PREDICTION DIAGRAM LA REUNION (E) (SHEET 2 OF 2)

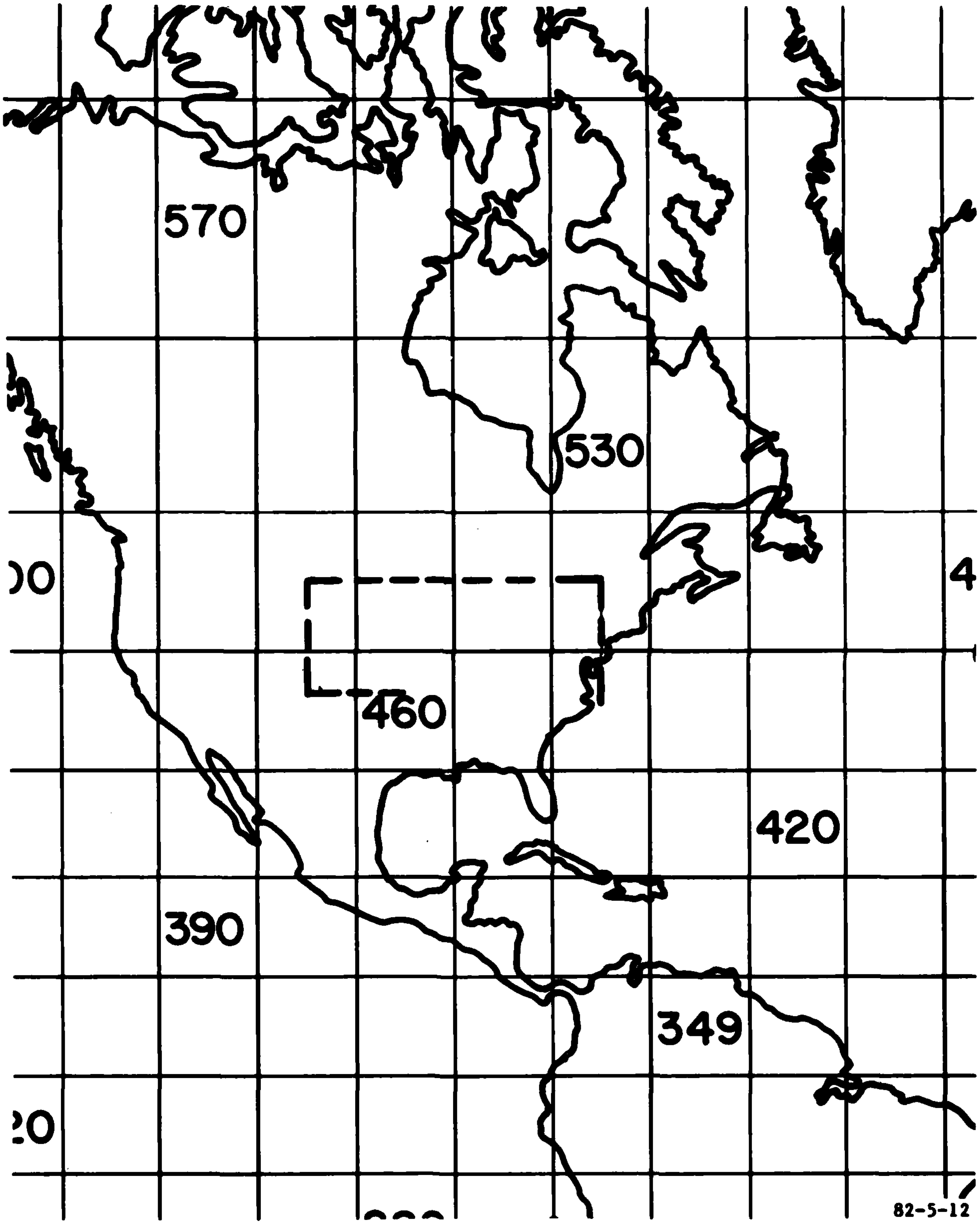


FIGURE 12. FLIGHTPATH FOR CONTRIBUTOR NUMBER 2, CONTINENTAL U.S., SPRING 1980

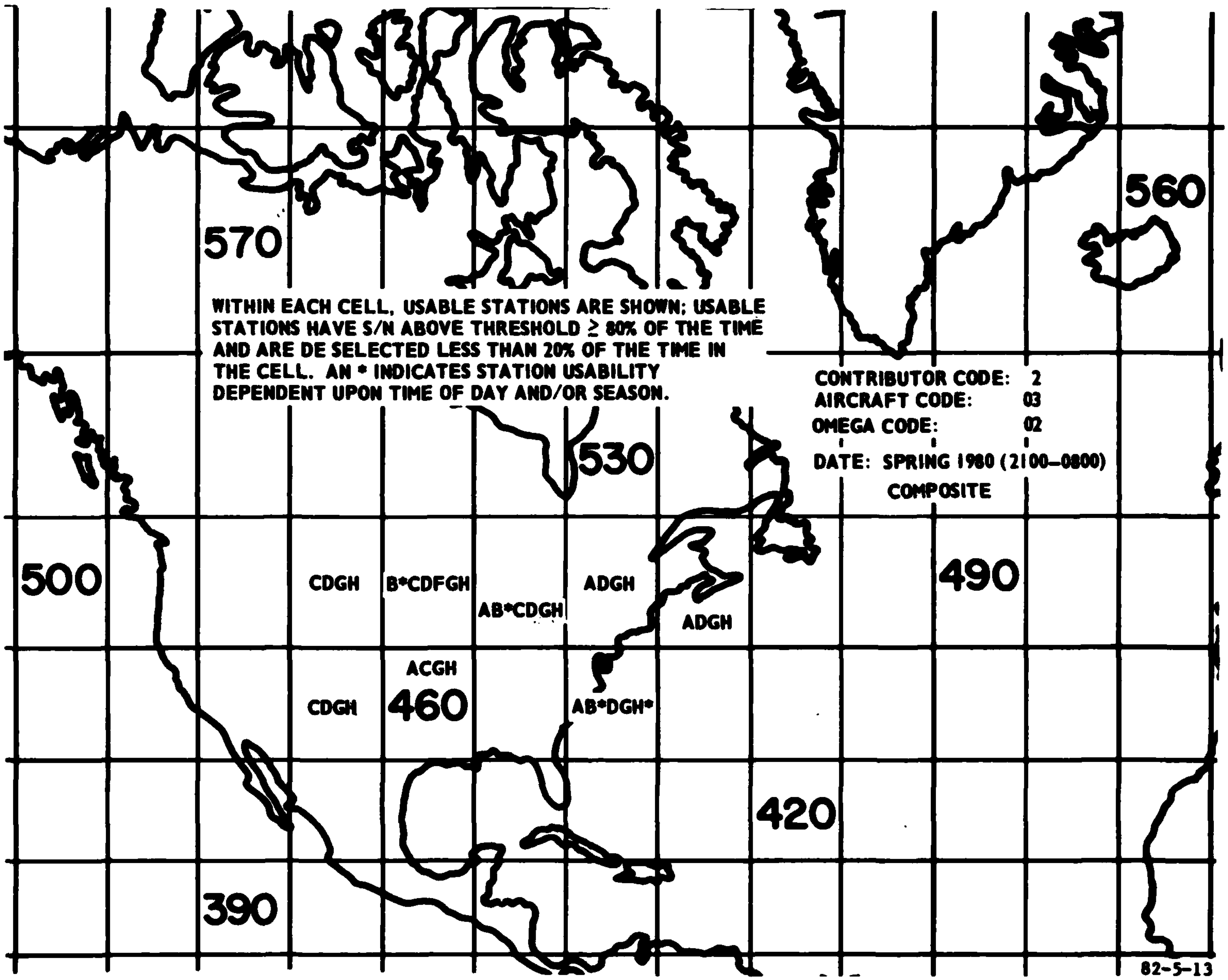


FIGURE 13. OPERATIONALLY USABLE SIGNALS: CONTINENTAL U.S., SPRING 1980

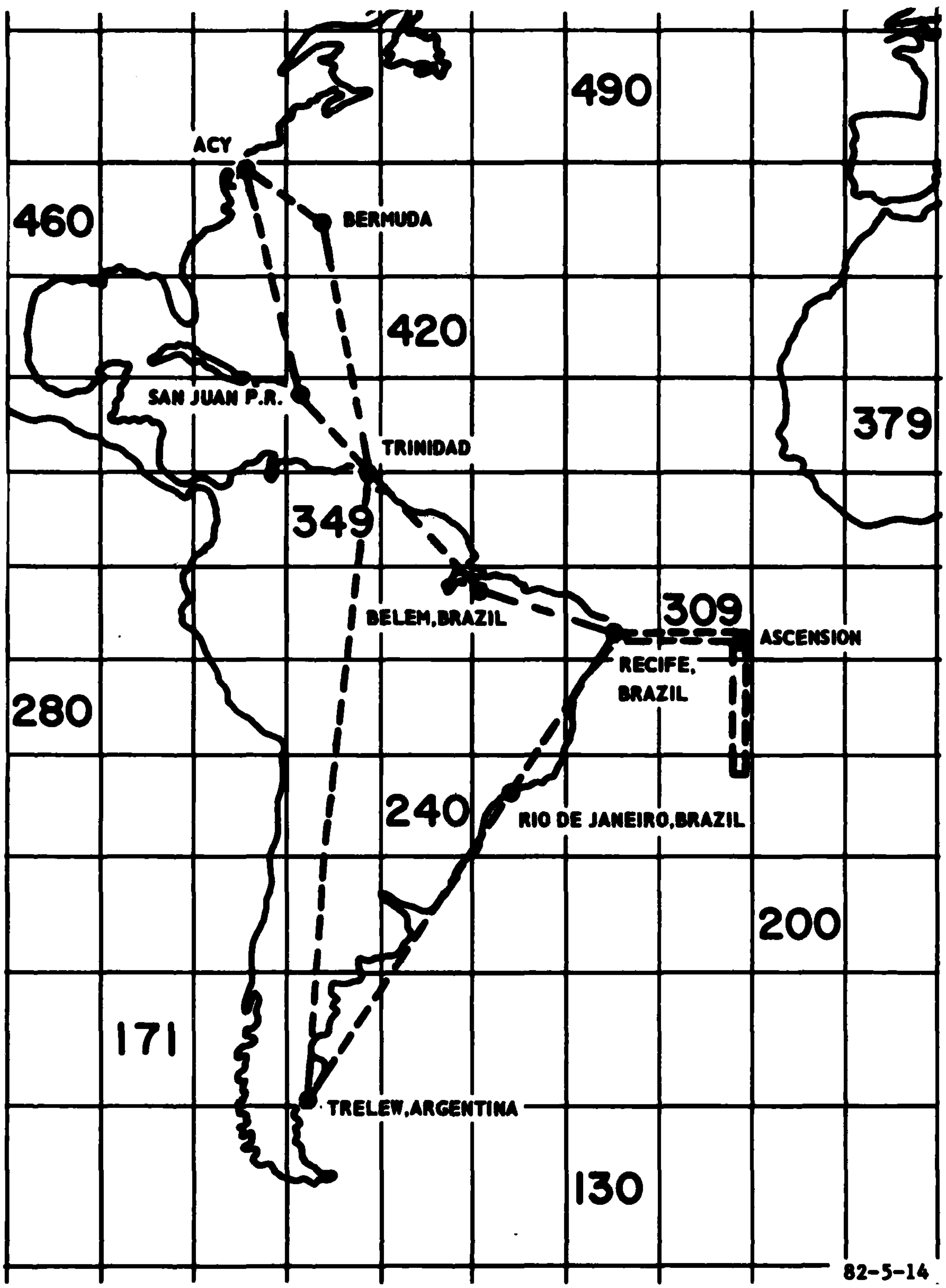


FIGURE 14. FLIGHTPATH FOR CONTRIBUTOR NUMBER 3, SOUTH AMERICA, SPRING 1980

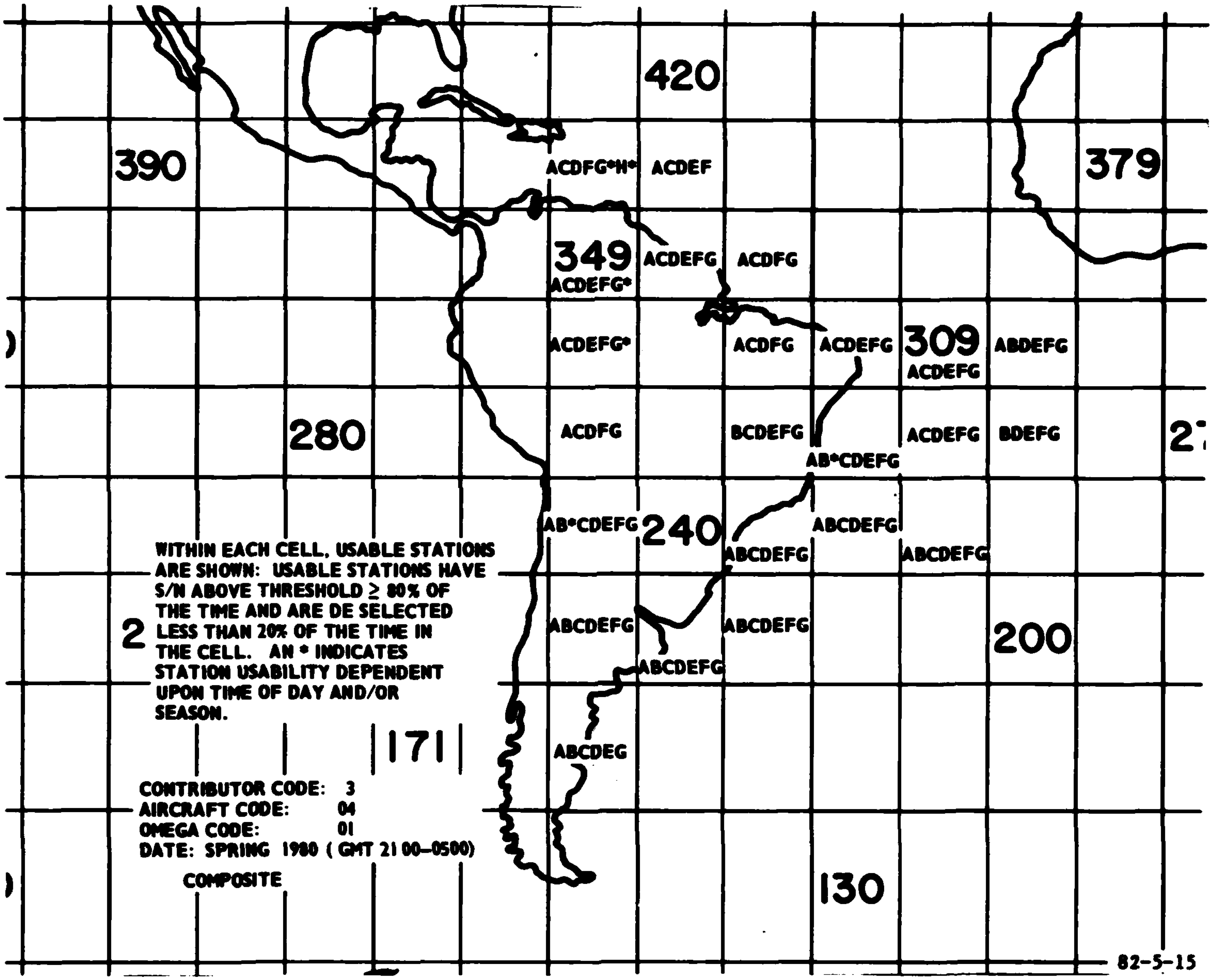


FIGURE 15. OPERATIONALLY USABLE SIGNALS: SOUTH AMERICA, SPRING 1980, CONTRIBUTOR OMEGA SET 01

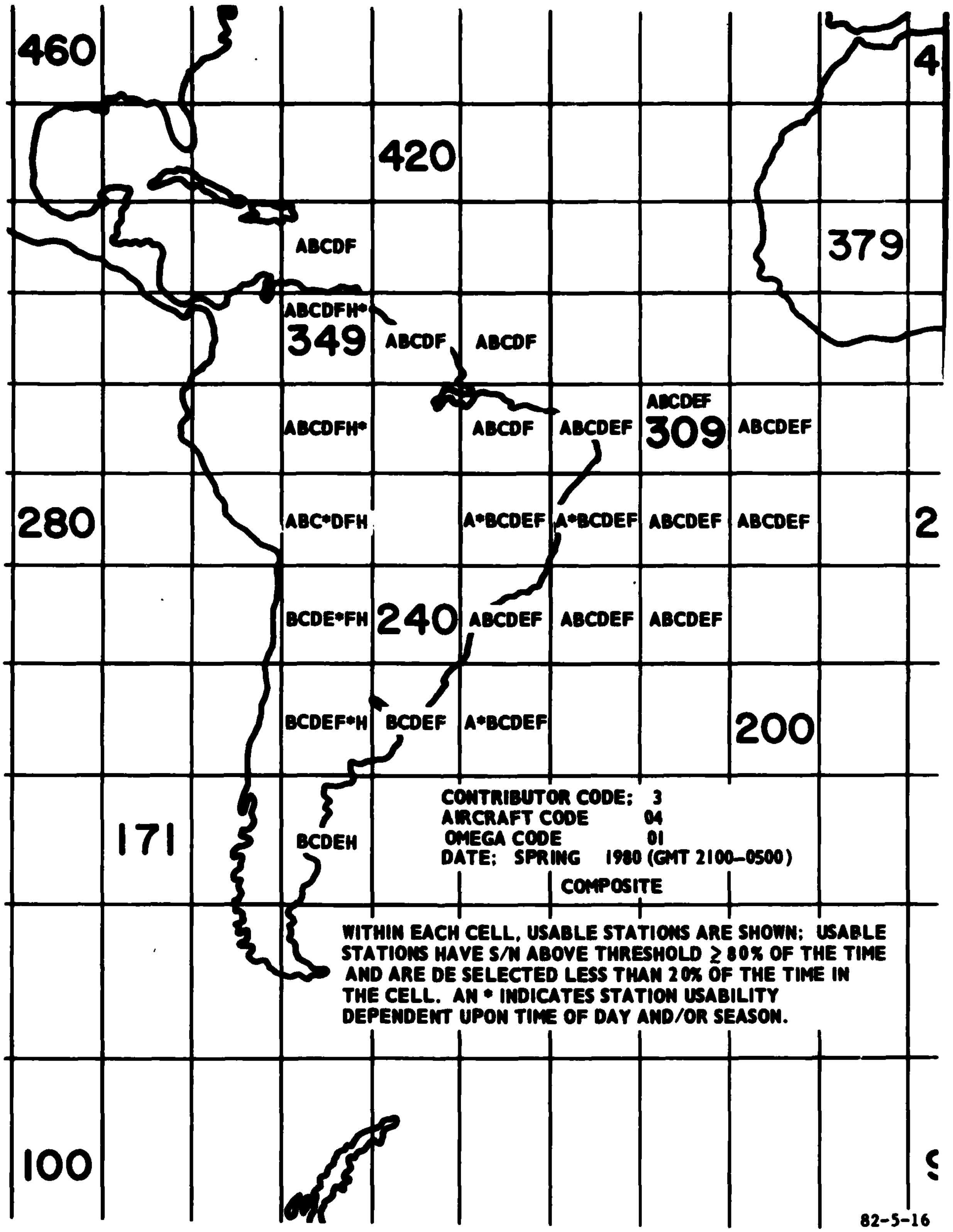


FIGURE 16. OPERATIONALLY USABLE SIGNALS: SOUTH AMERICA, SPRING 1980, CONTRIBUTOR OMEGA SET 03

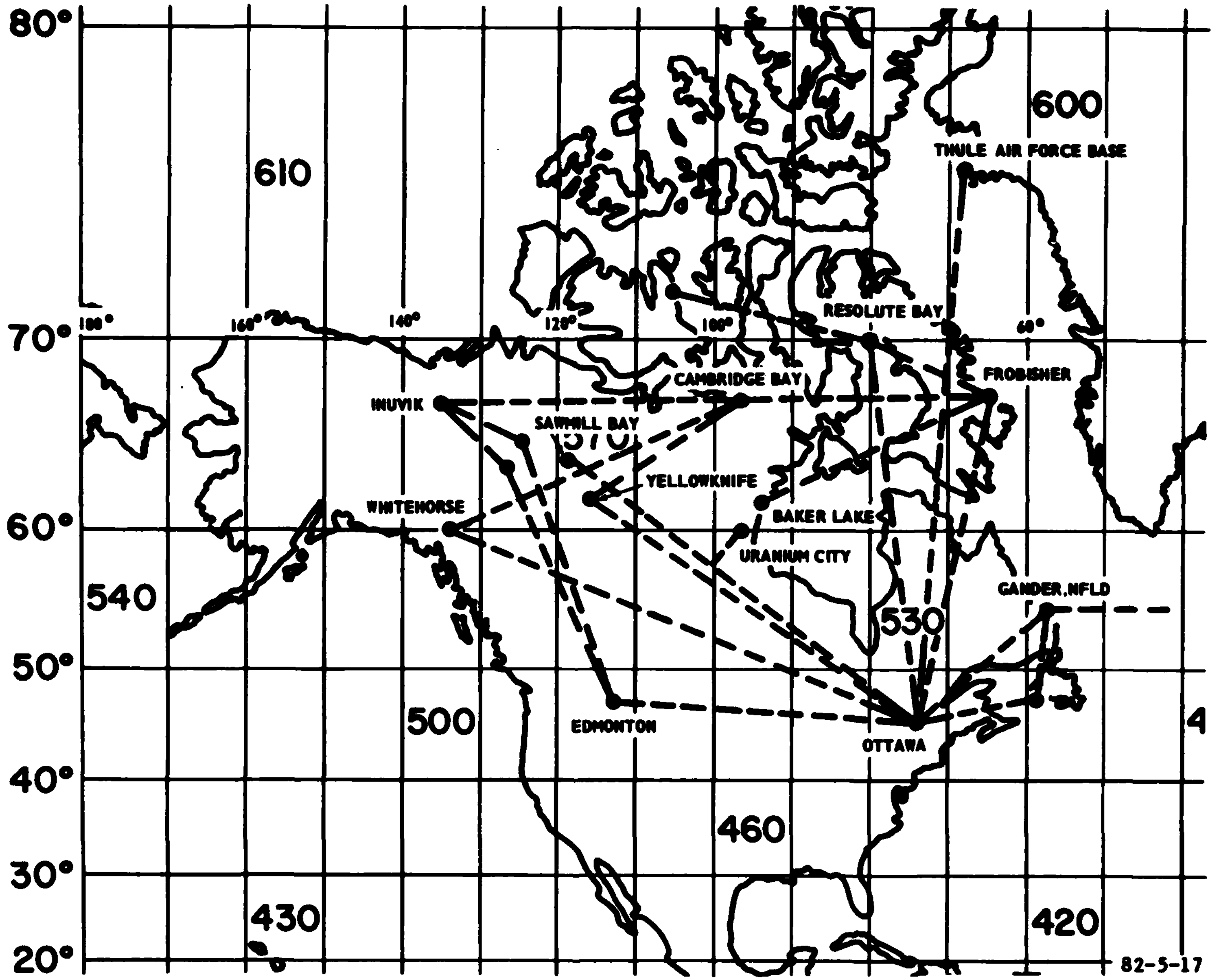


FIGURE 17. FLIGHTPATH FOR CONTRIBUTOR NUMBER 5, CANADA

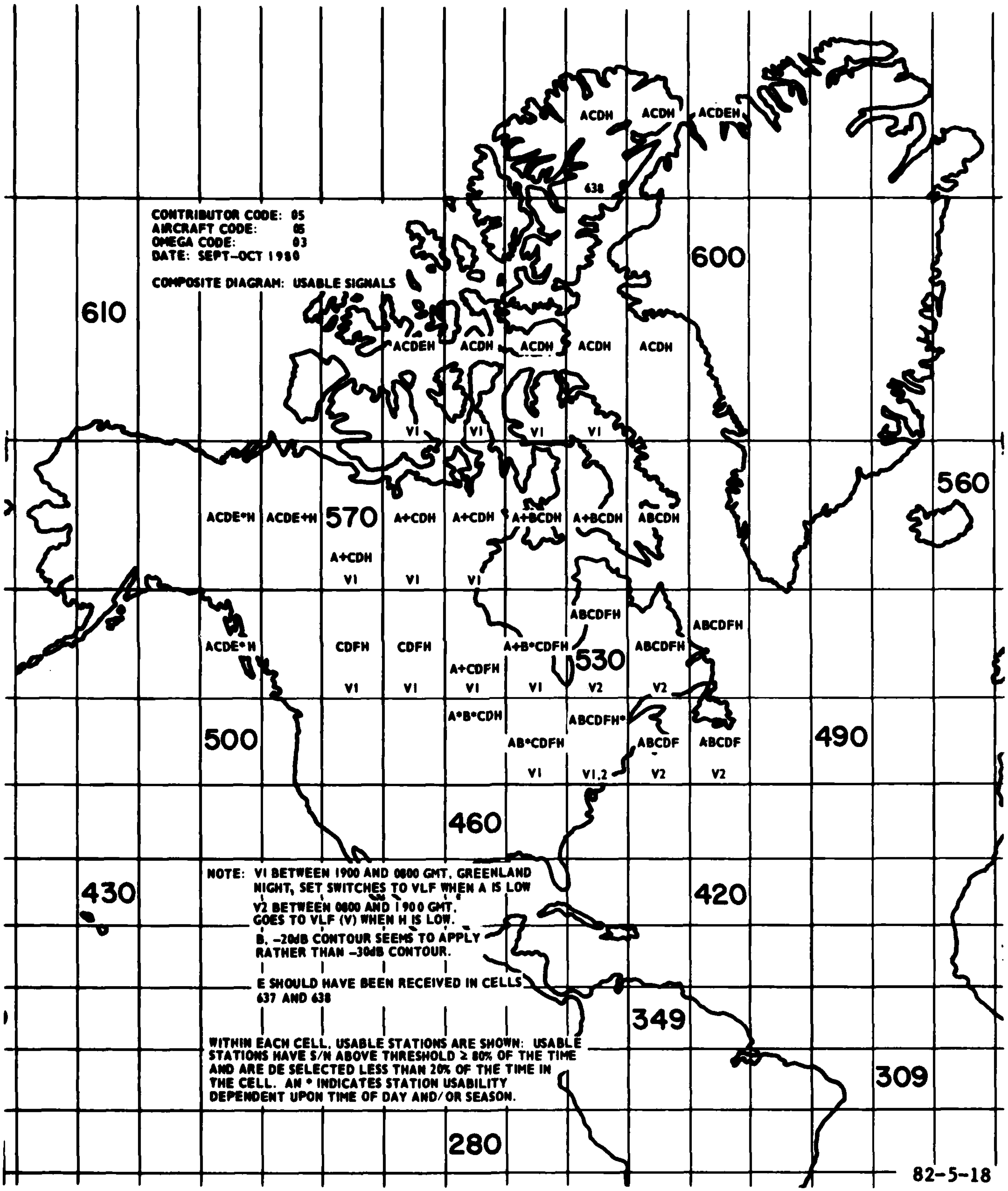


FIGURE 18. OPERATIONALLY USABLE SIGNALS: CANADA-GREENLAND, FALL 1980

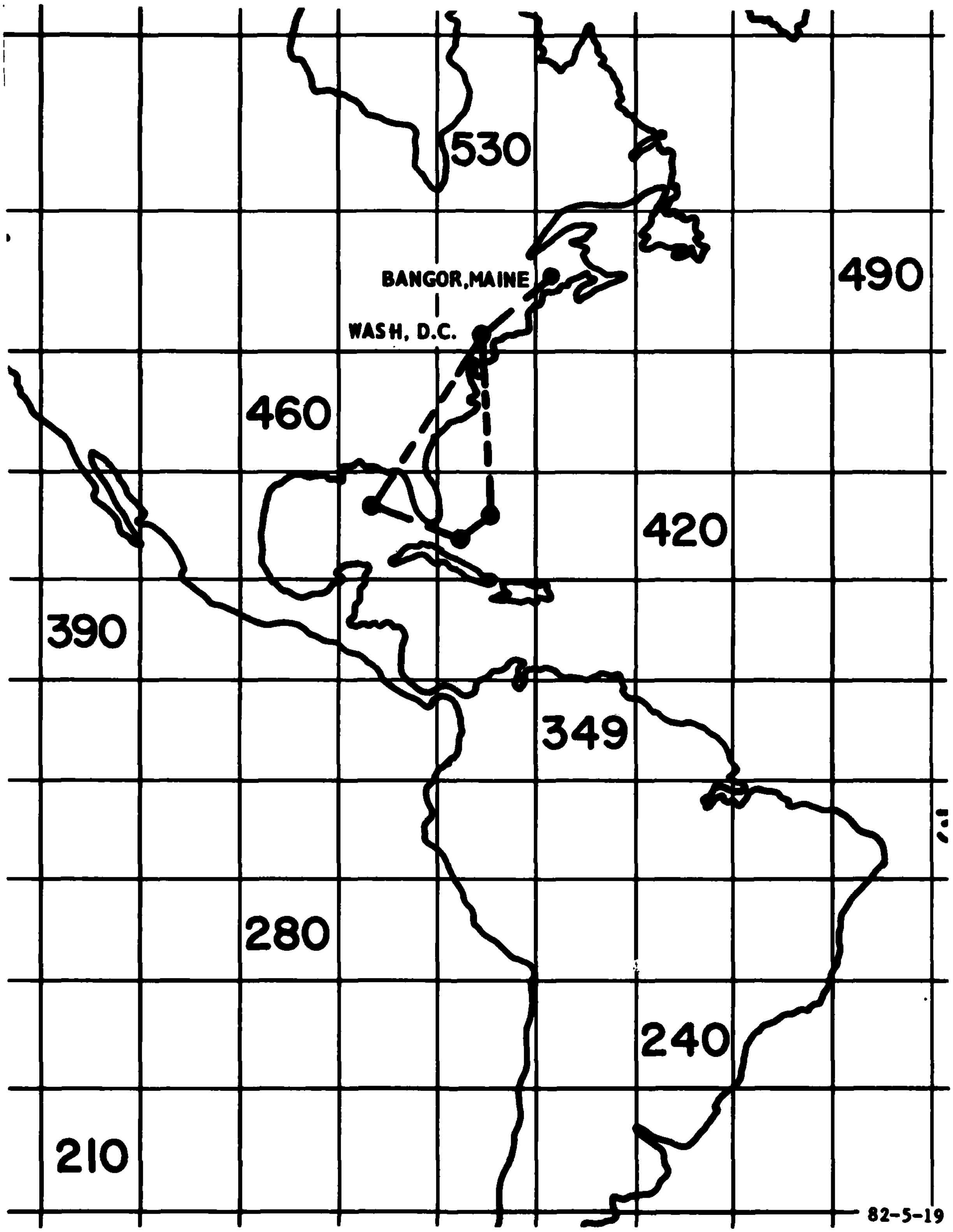


FIGURE 19. FLIGHTPATH FOR CONTRIBUTOR NUMBER 6, U.S.-CARIBBEAN

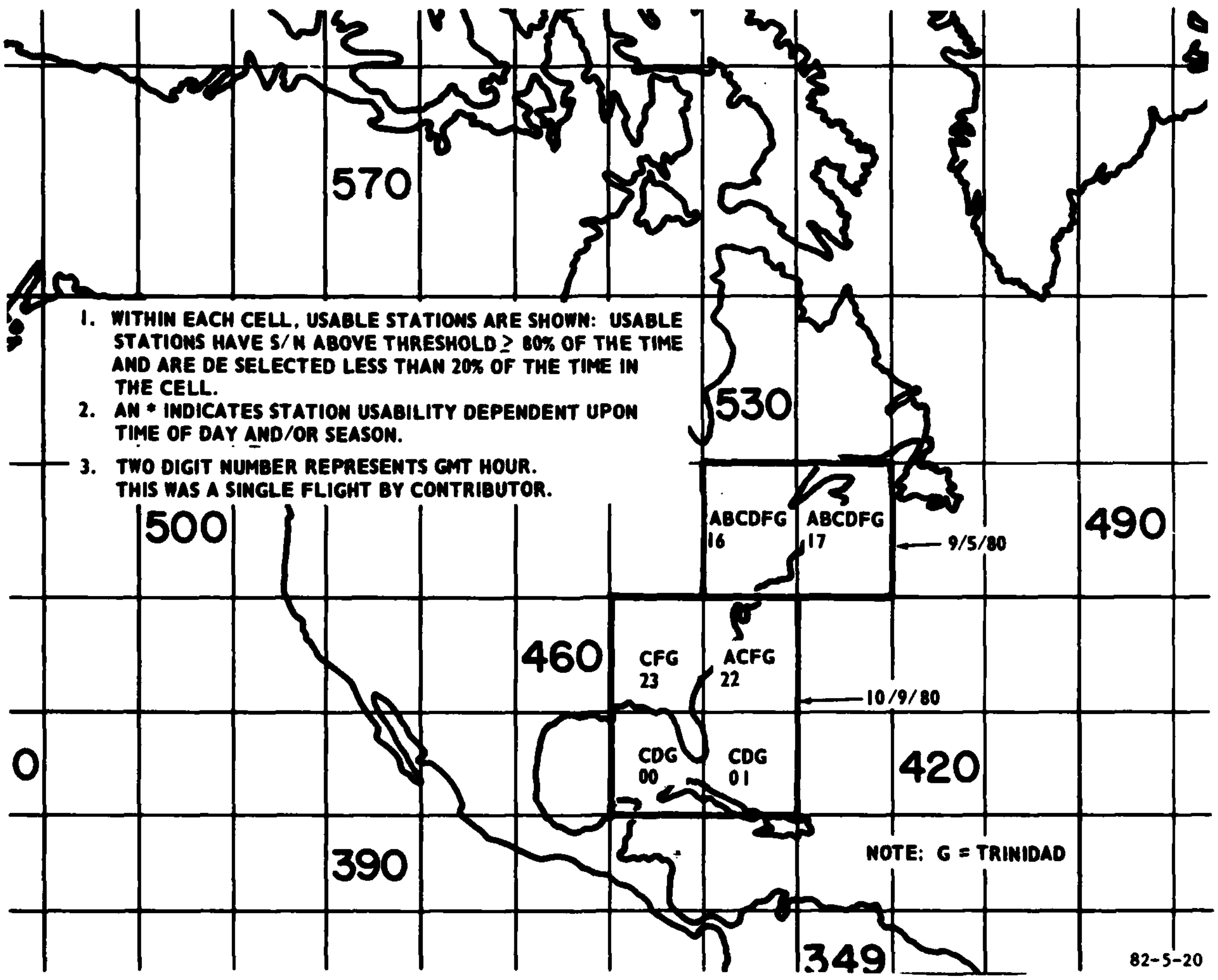
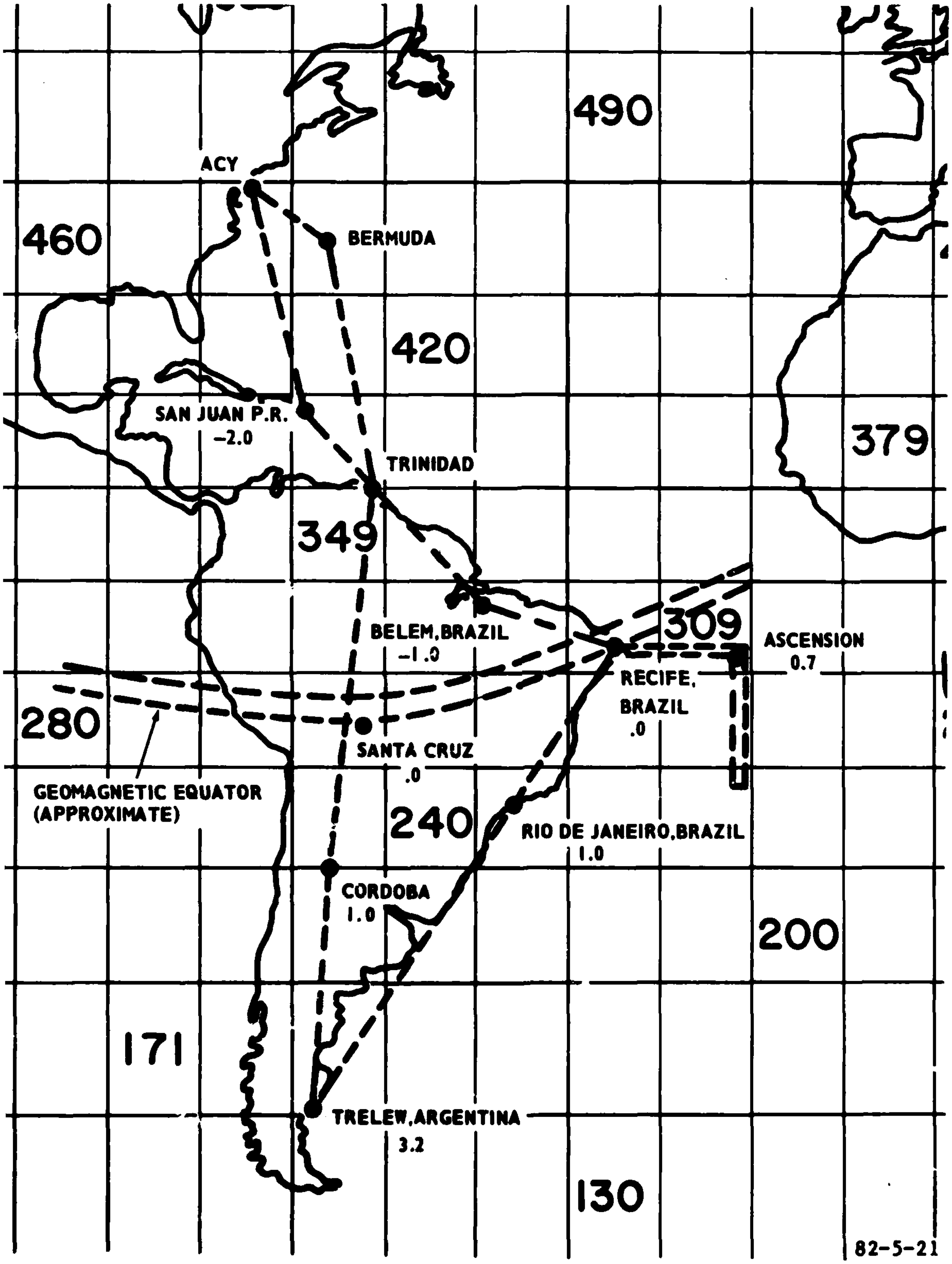


FIGURE 20. OPERATIONALLY USABLE SIGNALS: U.S.-CARIBBEAN, FALL 1980



E 21. ROUTE MAP SHOWING OMEGA NORTHING ERROR LOCATIONS AND MAGNITUDES